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THE EVALUATION OF STUDIES OF FLIGHT PERSONNEL OF THE GERMAN LUFTHANSA ON THE QUESTION OF THE STRESS DURING FLIGHTS ON THE SHORT EUROPEAN ROUTES

K.E. Klein, H. Brüner, P. Kuklinski, S. Ruff and H.M. Wegmann

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16. Abstract

Medical studies were undertaken in 1971-1972 on the stress experience by the cockpit crew working the short routes in Europe and a special attempt was made to discover whether s signs of a summation of stress due to flight work become visible during a circuit of several days. For this purpose the pulse and respiratory rates were determined for 22 crew members as an indication of the acute stress occurring during the flight and the amount of "stress hormone" in the urine as an indication of the extent of total stress in an extended study period.

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Foreword

Medical studies were undertaken on the stress experienced by the cockpit crew working the short routes in Europe and a special attempt was made to discover whether signs of a summation of stress due to flight work become visible during a circuit of several days.

For this purpose the pulse and respiratory rates were determined for 22 crew members as an indication of the acute stress occurring during the flight and the amount of "stress hormone" excretion in the urine as an indication of the extent of total stress in an extended study period.

The results point to a medium high stress for flying in the cockpit of a B 737. It was also noticeable that even during the sleeping periods between the flight assignments there was an increase in the excretion of the stress hormone. No indication was found, however, for an increase in stress over the duration of the circuit.

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REPORT DLR 355-74/2

THE EVALUATION OF STUDIES OF FLIGHT PERSONNEL OF THE GERMAN LUFTHANSA ON THE QUESTION OF THE STRESS DURING FLIGHTS ON THE SHORT EUROPEAN ROUTES[1)]

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I. Introduction /4*

The reactions of the human organism during flights of commercial aircraft have repeatedly been the object of extensive medical studies. In such cases, however, more attention was paid to the routes with long flight times, time shifts or changes in climate [1,3,8,13, 14, 22, 29, 30, 32, 33, 36].

The special type of working stress due to multiple take-offs and landings during one day and the effect of repeating this stress several times within a short period during a circuit of several days, as is characteristic for a flight assignment on the European routes, has hardly been the subject of medical studies up to now as far as we know. Therefore, in the studies reported upon here the main emphasis was placed on the applied methods and the type of evaluation on the estimation of the influence of the factors typical for this work. The aim was especially to explain within the framework of the situation given at the place of work in such studies whether the psychophysiological reactions of the members of the cockpit crew provide any indication for a summation of stress in connection with flying during work.

*Numbers in the margin indicate pagination in the foreign text.

1) The studies were carried out as a commission of and the the support of the German Lufthansa. These were planned, prepared and carried out in 1970-72 by the chairman of section 02 at that time, Prof. H. Brüner, with the cooperation of P. Kuklinski.

II. Experimental Arrangement and Methods

For this purpose measurements were taken for evaluation with 22 crew members (11 pilots and 11 copilots) from December 1971 to October 1972, divided about in half on two different circuits of the German Lufthansa flight plan XB and ZD with the B 737. Measurements were carried out on three days each during these circuits; since three to five scheduled flights are carried out each day, physiological and biochemical data were gathered in this program during a total of 124 different flights with just as many take-offs and landings. Table 1 provides a survey on the flight paths of the two circuits.

Pulse and respiration rate were determined continuously on each /5 flight from the time of readiness for departure (the last 5 minutes at the terminal during flight preparations) until about 5 minutes after taxiing (back to the terminal). A measuring device has been developed for these measurements, permitting simultaneous measurement of both parameters without obstructing the work of flying for both pilot and copilot by using a nose clip for continuous recording in rate per minute [2,31]. An approximate total of 15,000 pulse rates and about as many respiration rate measurements were carried out with this procedure.

Moreover, urine of both crew members was continuously collected during the entire circuit and later analyzed with known methods [5,28] for the content of so-called stress hormones (adrenaline, noradrenaline and corticosteroids). Urine samples were taken in this case in the morning immediately after arising, 15 minutes before the first take-off and 15 minutes after each landing, as well as additionally three hours after the final landing and shortly before retiring for bed. A total of more than 700 urine samples were collected and almost 5,000 chemical analyses were carried out on these samples.

It was necessary to [illegible] the pulse and respiration rates in the following manner in order to estimate the reaction of circulation and respiration during different phases of a flight:

(a) Before take-off (from the start of measurements until 3 minutes before the machine takes off from the runway); (b) during take-off (from 2 minutes before the take-off until 6 minutes after leaving the ground); (c) during the flight; (d) during the landing (from 6 minutes before landing on the ground until 2 minutes after landing) and (e) after the landing (from 3 minutes after making contact with the ground until 5 minutes after conclusion of taxiing).

When the physiological parameters are classified in phases in the following, the number is always the arithmetic mean value of pulse and respiration rate for the individual phase. In addition to this classification according to flight phase, the pulse and respiration rates were also considered separately for the minute of touch-down on the runway.

The excretion of stress hormones in the urine was either compiled for the entire day or separately for the phase of cockpit activity and rest period at night. Control values were compared, gathered from a group of subjects carrying out an activity comparable to that in the cockpit, but around the clock every three hours for 45 minutes. The procedure differed only for the periods of sleep, as results were employed here for a comparison with standard values, gathered from the crew members themselves during a sleeping period in the night before beginning the flights, i.e. without previous flying work. The percentual deviations from the control values calculated for each hormone in the study were compiled to a stress index by averaging. /6

Finally, statements of the crew members on weather conditions, special events and the subjective perception of stress were gathered by means of a questionnaire, permitting an estimation of the degree of difficulty of various flights by averaging the data.

III. Presentation of the Results

The results gained from the preliminary evaluation of the data with the above-described methods can be described as follows.

1. Personal Data of the Subjects

Since age and flight experience may modify the physiological reactions during flying, it is necessary to survey these parameters. This information is contained in Table 2. It can be seen from the table that in both circuits the pilots participating in the studies were older and had more flight experience than the copilots, as expected. On the average, the age difference was about five years and the difference in number of hours flown corresponded to the ratio 1:4 for all aircraft types, or 1:2.5 for the B 737 (table 2, left-hand portion).

However, the fact that age and number of hours flown hardly differ when these are classified according to the individual activity in the cockpit at the time of our measurements (Table 2, right-hand portion) is of greater significance for the subsequent estimation of physiological changes. The reason for this may be found in the fact that pilots and copilots had flown the machine in about the same distribution during the flights employed in the measurements. Accordingly, it cannot be expected that age and flight experience have a substantial statistical effect on the average values of the physiological reactions. /7

The situation is different, however, for the variations in the values of pulse and respiration rates at rest (also Table 2), ascertained both between the two circuits on the whole and also between the group of the persons involved in flight and those not flying. In both situations, in the first case probably stemming from different times of the day (XB; mornings, ZD: afternoons) and in the second probably based more on individual differences, an effect on the size of the values measured later during flight may be expected.

2. Pulse and Respiration Rates

The pulse and resiration rates, given for the circuit XB in Table 3 and for the circuit ZD in Table 4, is connected in a characteristic manner both with the various phases of a flight and generally also with the individual work of the subjects in the cockpit.

The highest values were found in both cases "during the landing" and then especially in the minute of "touch-down on the runway". For the circuit XB these average 85 to 90 beats/min and 18 to 19 breaths/min and are higher on the average of 10-15 pulse beats and 2 breaths for the circuit ZD with 95-105 beats/min and 21-22 breaths per minute.

This difference between the circuits is probably based mainly on the difference in time of day of the circuits. From our studies /8
with F 104 pilots in a flight similator [15,26] , we know that both the values at rest and the reaction of circulation and respiration are lower in the morning than in the afternoon for an objectively identical flying activity. Therefore, it is not necessary to assume that the afternoon circuit, ZD, involved more stress than the circuit XB flown in the morning solely on the basis of the differences in rates of pulse and respiration. The statements of the crew members about the subjective response to stress contradict such an assumption, as will be discussed later.

Furthermore, it is noticeable in the comparison between the two circuits, that the difference between actively flying and non-flying pilots amounts to 7 beats per minute during the afternoon circuit in the middle of the flight and even rises to 12-17 beats per minute for the most strenuous phase of the flight, the landing, while there is practically no difference between flying and non-flying personnel on the average in the XB circuit during the morning and the difference even for the landing phase only amounts to 3-5 beats per minute.

An explanation for this difference is provided by the differences in the values at rest (Table 2), already mentioned in III.1, Personal Data of the Subjects. When these differences are standardized by calculating the percentual increase in pulse rate during the flight compared to the values at rest (Table 5), the increases in the morning flight are still all less because of the time of day; however, the differences in connection with flying or non-flying personnel do become clear.

In connection with the question of a summation or accumulation of stress over several days, it is interesting to note that pulse and respiration rates, as well as the percentual increases of these parameters on various days of a circuit are very similar and certainly do not make any tendency connected to the duration of flight work apparent.

3. Hormone Secretion /9

When the hormone secretion is compiled in the manner given in section II on methods and a stress index calculated from the percentual deviations of control values, an increase in hormone secretion results for both circuits in the time "during the flight", amounting to 100 % on the average for circuit XB and 68 % for circuit ZD (Tables 6 and 7). These changes are also found, although to a lesser degree, in the values for the day, i.e. for the 24 hour period with the increases here amounting to 63 % or 36 % on the average for all flights (Tables 8 and 9). Finally, there is also an increase in hormone secretion during the "periods of sleep". The increase here in comparison to the controls is 28 % for XB and 20 % for ZD, but this is relatively slight in comparison to the two other phases (Tables 10 and 11). It is still remarkable, that even in the rest periods between the flight work there is an increase in hormone secretion for both circuits compared to the amount in the night before the flights.

The relative higher rates of hormone secretion observed in all three phases on the average for the XB is noticeable in the comparison between the two circuits. The difference for the stress index during the flights and in the 24 hour value amounts to about 30 %, for the periods of sleep 8 %.

This difference can first be considered the expression for a greater stress on the crew of the circuit XB. However, the effect

of the daily rhythm on the results cannot be disregarded in this connection, just as in the reactions of circulation and respiration. It was proven in studies with military pilots [7,8] , that differences in hormone secretion depending on the time of day also result as a reaction to the stress of flying. According to the results of these studies it must be assumed that slighter increases in hormone /10
secretion may be expected for individual hormones after flights during the afternoon (12:00 to 6:00 p.m.) and evening (6:00 p.m. to midnight) than after flights during the morning (6:00 a.m. to noon). The rather slight differences in the total secretion of hormones between the circuits in our studies are therefore explained.

The different distribution patterns in the reaction of the two hormone systems corticosteriods and catecholamines (adrenaline and noradrenaline), however, cannot be explained well by the effect of daily rhythm. The fact that the secretion of catecholamines (with the exception of the"conjugated adrenaline"), above all, increased much more in comparison with the controls for the flights of the XB circuit than for the ZD flights (Tables 6 and 7) and a similar difference also remains for the total secretion on one day (Tables 8 and 9) points more toward the greater stress index for the XB at least partially also caused by a greater work load on the crew. In this connection it is also significant to know that according to the subjective evaluation of the crew 35 % of the take-offs and landings of the XB circuit required concentration and effort beyond the usual amount, while that was the case of 14 % of the time in circuit ZD.

When the stress index of individual flight days are compared with one another, it becomes apparent that the increase in hormone secretion on the first flight day in both circuits in the three phases compiled by us, flight - 24 hours - sleep, was less marked in comparison to the control values than on the two subsequent days. It may then be assumed that the first day of flying is generally less stressful than the other days. Moreover, an increase in stress can also be assumed from the difference between the first and the second day, in contrast to the findings for cir-

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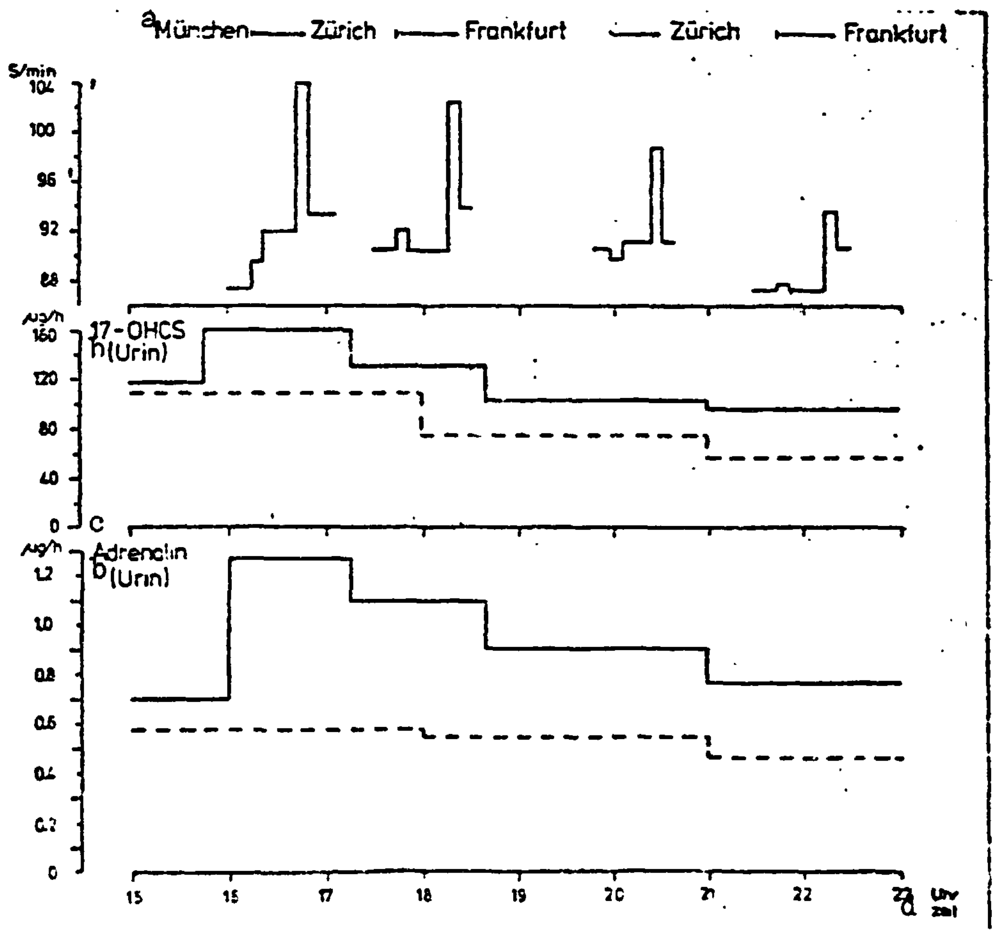
culation and respiration, but also an increase in the work load in the course of the circuits. Contradicting such an assumption, however, is the fact that the stress index demonstrates more of a drop than a rise on the third day of both circuits; in addition, the subjective statements on the difficulties occurring on different days of the flight do not point to such a tendency. Therefore, it is probably more correct to assume that the observed differences are more accidental, insofar as the first flight day examined by us had the lower work load in both cases. This assumption is supported by the fact that the period defined by us as the first flight day was already the second day of flight work for a portion of the examined crew members and higher rates of hormone secretion were observed in this crews on the first day of work than later. /11



Pulse Rate and Hormone Secretion for Crew Members of the B737 on the European Short Routes

(--------- Hormone Secretion of the Control Group)

Key: a. Munich b. Urine c. Adrenaline d. time

IV. Discussion of the Results and Conclusions /12

Pulse and respiration rates are physiological parameters, reacting almost immediately to an acute load on circulation and respiration and generally return to normal rapidly after this load is no longer present. Behavior during muscular work is typical for this response.

Even without appreciable physical work, however, these parameters may change with a psychological-emotional stress, e.g. as the result of increased concentration, a greater feeling of responsibility or the subjective experience of risk without a corresponding rise in functions in circulation and respiration, for example because of increased need for oxygen. Pulse and respiration rates are then increased as the expression of an increase in exitation of the central nervous system and, in this sense, provide an indication of the size of a psychological stress not connected with muscular work.

The stress hormones also permit such an assumption in a similar manner, but in contrast to the pulse and respiration rates these hormones provide more indication of the extent of the total stress in the period of the study instead of the short-term acute stress, when they are measured in urine and not in the blood. Fig. 1 demonstrates this point in a characteristic manner, using the example of a flight day in our study.

When under this aspect the level of the pulse rates measured by us in the cockpit of the B 737 is now compared with the pulse rates observed in other aircraft types and during non-flying work loads (Tables 12a and 12b), the results are medium-sized changes, on the average, but even in the maximum values at the time of highest stress during the landing. The increase in pulse rate of 20-35 % over the value at rest is easily comparable to the value /13 measured in the cockpit of a B 707 [19] or a DO 27 [11] and is only slightly more than the pulse rates observed at the wheel of a passenger car during long trips [18] during intensive administration work [24].

It should now be clear that the estimation of the intensity of stress through physiological reactions is the result of the amount of work load on a certain person. It is therefore obvious that the amount of stress is modified by individual factors. In this connection, the fact must be noted, that the physiological reactions to the same amount of external load become smaller as experience is gained [10,11] , but also that in individual cases reactions deviating considerably from the average may occur.

For example, it can then be understood that continususly high pulse rates (on the order of "Extreme Individual Values" as these are listed in the table for our studies) were measured for a 24-year-old inexperienced copilot, who had a total of only 580 flight hours (280 in the B 737), and similar values of a 28-year-old co-pilot with more flight experience (3770 hours flown, 370 hours in the B 737), flying under supervision during the entire circuit, i.e. carrying out an inspection flight.

The determination is interesting for the cause of the reaction of pulse and respiration rates and therefore for the type of work load that even in the flight simulator very similar pulse and respiration values are measured, as we discovered in cockpit of the B 737 [10,15,26]. In our opinion two conclusions may be drawn from this:

1. Instrument flight in a simulator is "genuine" flight in the aspect of demands on the individual, disregarding the fact that a subjective feeling of risk generally is lacking. The differnece between the pulse rates in an F 104 simulator and military jets flights (no. 8 and no. 3 in Table 12) illuminate what is meant in this connection with the influence of the feeling of risk. /14

2. The increase in pulse rate during routine flight work in the cockpit of a B 737 is caused less by a feeling of risk, but more by the increase in concentration levels and sense of responsibility.

This becomes clear in a comparison with activities accompanied by a large subjective experience of risk: professional racing drivers [27], parachutists [21,25], some helicopter maneuvers [20] and, as mentioned above, flying military jet aircraft in difficult missions [12, 16]. The pulse rates observed in these cases often are around 200 beats per minute, although only for a short time; on this order of magnitude they no longer have anything in common with the pulse rates observed in the group of comparable activities, to which flying a B 737 also belongs.

In estimating the reaction of the stress hormones, similar conclusions are reached, although there are fewer possibilities for comparison here than for pulse and respiration due to a lack of appropriate data in literature.

In especially risky activities such as car racing [27] and a six-hour transatlantic flight with jet aircraft of the type 104, requiring several refuelings in the air [17], the increase in secretion of catecholamines approaches 700 % (for F 104 pilots) up to almost 20 times (for car drivers in races). In comparison, the increases for the B 737 crew (in extreme cases on the magnitude of 180 %) are almost modest. It should not be forgotten, however, that the two above-mentioned examples are extreme loads and it can /15 be reasonably predicted that no person could be subjected to them constantly at work, i.e. in a 5-day work for years.

Measurements comparable to our studies have not yet been undertaken in civilian aeronautics, especially in relation to routine assignments. In comparison, there are already some results in the area of military application; however, these results are not usually comparable directly to the situation in our study, since they are in connection either with individual short flights of 30-45 minutes [4,23,34,35] or with long flights with a maximum of one stop [7,8].

Increases in the secretion of noradrenaline and adrenaline of up to 200 % were observed after short flights, which were not combat assignments, but rather training flights. In the case of long military flights, a differentiation must first be made between transport aircraft and combat aircraft. In routine assignments of transport aircraft there may be increases in the hormone secretion in the crews, comparable to the values we ascertained, but some are also considerably above our values (adrenaline up to 320 %, noradrenaline and corticoids up to 200 %). Flights with combat aircraft (flight times of 6 or more hours) generally led to higher rates of hormone secretion, amounting up to the above-mentioned 700 %, depending on the degree of difficulty [17].

Especially interesting in this connection are studies carried out with air traffic controllers [9]. After a shift of seven hours - a period of time approximately in agreement with the flight working times studied by us - increases in hormone secretion up to 400 % were found, i.e. 2.2 times higher than the levels we observed in the present study.

In summary, the conclusion can also be reached on the basis of the rates of hormone secretion that flight work on the B 737 represents a medium professional work load. Also, no evidence was found here that carrying out this work for several days during a circuit systematically alters the physiological criteria measured by us in the direction of increasing stress. /16

The fact that the rate of hormone secretion during the circuit also stays high during the night may result from a slow reduction in the raised level of activity during the day, or a raised level of activity of this system may even continue during the night in comparison to the behavior before the flights. Further studies are necessary to find an answer for this question.

In the same connection, however, it seems necessary for us to point out that the hormone secretion in the night before beginning the circuit was in good agreement with the values of the control group. The rest periods at home therefore apparently lead to sufficient relaxation.

REFERENCES

1 Barwood, A.J., "The Independent Investigation oi Workload and Working Conditions of BEA Pilots," Flying Personnel Research Committee, FPRC/1177 (a), November 1961 /17

2 Brüner, H. and H. Hohlweck, "A New Procedure for Recording Pulse and Respiration Rate While Flying," DLR-FB 73-15, p. 21-33, 1973.

3 Bugard, P., "Study of Hormones and Metabolism of Fatigue. II. Personnel Travelling on Intercontinental Flights," Annales d'En ,crinologie 22, p. 1008 (1961).

4 Debijadji, R., L. Pesovic and V. Varagic, "Evaluation of the Sympatho-adrenals Activity in Pilots by Determination of Urinary Catecholamines During Supersonic Flight," Aerospace Med. 41, p. 677-679 (1970).

5 Dierlich, U., Auswirkungen der Zeitverschiebung auf die Tagesrhythmik der 17-Hydroxycorticosteriode [Effects of Time Shifts on the Daily Rhythm of the 17-Hydroxycorticosteroids], Dissertation Univ. Bonn 1963, DLR-FB 73-58 (1973).

6 Gerritzen, F., "The Diurnal Rhythm in Water, Chloride, Sodium and Potassium Excretion During a Rapid Displacement from East to West and Vice Versa," Aerospace Med. 33, p. 697-701 (1962).

7 Hale, H.B., Clarence Anderson, A. Williams, E.W. Tanne, "Endocrine-Metabolic Effects of Unusually Long r Frequent Flying Missions in C 130 or C 135 B Air aft," Aerospace Med. 39, p. 561-570 (1968).

8 Hale, H.B., B.O. Hartmann, D.A. Harris, E.W. Williams, R.E. Miranda, J.M. Hosenfeld and B.M. Smith, "Physiological Stress During 50-Hour Doublecrew Missions in C 141 Aircraft," Aerospace Med. 43, p. 293-299 (1972).

9 Hale, H.B., E.W. Williams, B.N. Smith and C.E. Melton, "Excretion Patterns of Air Traffic Controllers," Aerospace Med.42 p. 127-138 (1971).

10 Hasbrook, A.H. and P.G. Rasmussen, "Pilot Rate During In-Flight Simulated Instrument Approaches in a General Aviation Aircraft," Aerospace Med. 41, p. 1148-1152 (1970). /18

11 Hoffmann, H., "Biotelemetric Studies in Pilots of Propeller Machines, Helicopters and Jets," Hefte zur Unfallheilkunde 91, p. 10 - 107 (1967).

12 Hoffmann, H., M. Koch, W. Schmückling, "Biotelemetric Studies of the Cardiovascular System in Jet Pilots during Flight to Determine the Different Stresses of Flying," ZBL.f. Verkehrs-Med. 14, p. 193-215 (1968).

13 Juin, G., "Considerations on the Increase of Fatigue Factors Concerning Air-Crew Flying on Jets," in Barbour-Wittingham (Ed.), Human Problems of Supersonic and Hypersonic Flight Oxford, Pergamon Press, 1962, p. 390.

14 Klein, K.E., H. Brüner and S. Ruff, "Studied on the Stress of Personnel on Long-Distance Flights with Jets," Report of the Results on the North Atlantic Route, DLR-FB 65-44 (1965).

15 Kroll, P., "The Portion of Tension due to Expectation in the Total Stress of Flying and its Dependence on Daily Rhythm measured by Physiological Parameters," DLR-FB 72-39 (1972).

16 Lewis, C.E., W.L. Jones, F. Austin and J. Roman, "Flight Research Program: IX Medical Monitoring of Carrier Pilots in Combat II.," Aerospace Med. 38, p. 581-592 (1967).

17 Marchbanks, V.H., H.B. Hale and J.P. Ellis, "Stress Responses of Pilots Flying 6-Hour Overwater Missions in F 100 and F 104 Aircraft," Aerospace Med. 34, p. 15-18 (1963).

18 Mayer, H., Untersuchung zur Frage der Belastung bei Kraftfahrzeugführern auf Langstreckenfahrten [Study on the Stress of Passenger Car Drivers during Long-Distance Trips], Dissertation, Univ. Bonn, 1969.

19 Nicholson, A.N., L.E. Hill, R.G. Borland and H.M. Ferres, "Activity of the Nervous System During the Let-down, Approach and Landing: A Study of Short Duration High Work Load," Aerospace Med. 41,-. 436-446 (1970). /19

20 Raabe, H., Biotelemetrische Untersuchungen des Herz-Kreislauf Systems bei Hubschrauben-Piloten zur Feststellung der unterschiedlichen fliegerischen Belastung [Biotelemetric Studies of the Cardiovascular System in Helicopter Pilots to Determine the differing Stresses of Flying], Dissertation, Univ. Bonn, 1969.

21 Reid, D.H. and J.E. Doerr, "Physiological Studies of Military Parachutists Via FM/FM Telemetry: The Data Acquisition System and Heart Rate Response," Aerospace Med. 41, p. 1292-1297 (1970).

22 Ruffel-Smith, H.P., "Independent Investigation of Work-Load and Working Conditions of BEA Pilots," Flying Personnel Research Committee FPRC/1177 (a) November 1961.

23 Sarviharju, P.J., M.E. Huikk, P.I. Jouppila and N.T. Kaerka, "Effect of Endurance Training on the Urinary Excretion of Noradrenaline and Adrenaline During Ground and Flying Activity," Aerospace Med. 42, p. 1297-1302 (1971).

24 Shane, W.P., "Electrocardiographic Survey of Routine Duty Days in Helicopter Pilots," in AGARD-ASMP Conference Proceedings No. 25, 9/1 - 9/7, 1967.

25 Shane, W.P. and K.E. Slinde, "Continuous ECG Recording During Free-Fall Parachuting," Aerospace Med. 39, p. 597-603 (1968).

26 Steinhoff, W.-D., "Variations in the Daily Rhythm of Circulation, Respiration and Gaseous Metabolism under the Stress of Flying," DLR-FB 72-49, 1972).

27 Taggart, P. quoted from Praxis aurea 6/10, p. 1-3, Ch. Boehringer Sohn, Ingelheim (1970).

28 Viktora, J.K., A. Bankal and F.W. Wolff, "New Automated Fluormetric Methods for Estimation of Small Amounts of Adrenaline and Noradrenaline," Analytical Biochemistry 23, p. 513-528 (1968).

Additions

29 Hauty, G.T. and T. Adams, "Phase Shifts of the Human Circadian System and Performance Deficit During the Periods of Transition; II. West-East Flight," Aerospace Med. 37, p. 668-671 (1966). /20

30 Hauty, G.T. and T. Adams, "Phase Shifts of the Human Circadian System and Performance Deficit During the Periods of Transition; II. West-East Flight," Aerospace Med. 37, p. 1027-1029 (1966).

31 Hohlweck, H. "The Technique of Measuring Respiration and Pulse Rate in Pilots," DFVLR-Nachr. 6, -. 251-253 (1972).

32 Klein, K.E., H. Brüner, H. Holtmann, H. Rehme, J. Stolze, W.-D. Steinhoff and H.M. Wegmann, "Circadian Rhythm of Pilots' Efficiency and Effects of Multiple Time Zone Flight," Aerospace Med. 41, p. 125-134 (1970).

33 Klein, K.E, H.M. Wegmann and B.J. Hunt, "Desynchronisation of Body Temperature and Performance Circadian Rhythm as a Result of Outgoing and Homegoing Transmeridian Flights," Aerospace Med. 43, p. 119-132 (1972).

34 Wegmann, H.M., "Biochemical Studies with F 104 Starfighter Pilots," in E.H. Graul (Ed.), Aktuelle Probleme der Luft- und Raumfahrtmedizin Present Problems of Aeronautic and Space Medicine, Verlag Eli Lilly Pharmazeutics, Giessen, 1969, p. 87-90.

35 Wegmann, H.M., K.E. Klein and H. Brüner, "The effects of flight stress on several components of the blood," Int.Z.angew. Physiol including Arbeitsphysiol. 23, p. 293-304 (1967).

30. Wegmann, H.M., J. Brüner, D. Jovy, K.E. Klein, J.P. Marbarger, A. Rimpler, "Effects of Transmeridian Flights on Diurnal Excretion Pattern of 17-Hydroxycorticosteroids," <u>Aerospace Med.</u> <u>41</u>, p. 1003-10 (1970).

	a Umlauf XB	a Umlauf ZD
b Tag 1	Köln - Hamburg	Frankfurt - Hamburg
	Hamburg - Kopenhagen	Hamburg - Köln
	Kopenhagen - Hamburg	Köln - Hamburg
	Hamburg - Köln	Hamburg - Paris
	Köln - München	
b Tag 2	München - Düsseldorf	Paris - Düsseldorf
	Düsseldorf - Kopenhagen	Düsseldorf - München
	Kopenhagen - Frankfurt	München - Düsseldorf
	Frankfurt - Nürnberg	Düsseldorf - München
b Tag 3	Nürnberg - Köln	München - Zürich
	Köln - London	Zürich - Frankfurt
	London - Köln	Frankfurt - Zürich
		Zürich - Frankfurt

Table 1: Flight Routes of the Circuits XB and ZD
Key: a. Circuit b. Day

c. Umlauf	a. Getrennt nach Dienstrang	N	[d] Alter	[e] Flugstunden Gesamt	B737	[f] Ruhe [g] Puls	[h] Atmung	b. Getrennt nach Tätigkeit	N	[d] Alter	[e] Flugstunden Gesamt	B737	[f] Ruhe [g] Puls	[h] Atmung
XB FDZ 06:00-14:00	Pilot	5	32,4	5380	1660	67,0	15,1	[i] Fliegende (28xP; 31xCoP)	59	28,7	3147	1289	67,0	14,1
	Co-Pilot	5	25,0	1236	776	68,6	13,4	[j] Nicht-fliegende	59	28,7	3426	1358	69,2	14,5
	Alle	10	28,7	3308	1218	67,8	14,3	[k] Alle	118	28,7	3287	1323	68,1	14,3
ZD FDZ 12:00 23:00	Pilot	6	32,4	4656	1611	70,6	16,0	[i] Fliegende (29xP; 36xCoP)	65	30,3	3000	1041	73,2	16,8
	Co-Pilot	6	28,6	1443	557	73,8	16,6	[j] Nicht-fliegende	65	30,7	3023	1153	71,1	15,8
	Alle	12	30,5	3049	1082	72,2	16,3	[k] Alle	130	30,5	3012	1097	72,1	16,3
XB + ZD	Pilot	11	32,2	4985	1633	69,0	15,6	[i] Fliegende (57xP; 67xCoP)	124	29,5	3070	1159	70,3	15,5
	Co-Pilot	11	26,8	1349	654	71,5	15,2	[j] Nicht-fliegende	124	29,6	3215	1251	70,2	15,2
	Alle	22	29,6	3167	1143	70,3	15,4	[k] Alle	248	29,5	3143	1205	70,2	15,4

abelle 2 [1]. Alter, Flugstunden und physiologische Ruhewerte der an den Untersuchungen beteiligten Besatzungsmitglieder. (Mittelwerte: Alter in Jahre, Puls- und Atemfrequenzen pro Minute).

See following page (19) for Key.

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Key for Table 2, page 18:
a. Divided according to rank
b. Divided according to activity
c. circuit
d. age
e. total hours flown on a B 737
f. at rest
g. pulse
h. respiration
i. actively flying personnel
j. non-flying personnel
k. all personnel
l. Table 2: Age, hours flown and physiological values at rest for the crew members participating in the studies (average values: age in years, pulse and respiration rate/min).

Key for Table 3, page 20:
a. Average for the flight phases indicated (beats or breaths/min)
b. Average for all flights on one day
c. Before take-off
d. During take-off
e. While travelling
f. During the landing
g. after landing
h. total average
i. During touch-down
j. day
k. actively flying personnel
l. non-flying personnel
m. total average
n. maximum individual values
o. Table 3: Pulse and Respiration for Cockpit Crew Members on the Short European Routes.

Circuit XB

Key for Table 4, page 21: Same as Key for Table 3 (above) with two exceptions

o. Table 4: Pulse and Respiration for Cockpit Crew Members on the Short European Routes

Circuit 3D

p. Flight Phase

	a. Mittel für die angegebenen Flugphasen (Schläge bzw. Atemzüge/min)							b. Mittel für alle Flüge eines Tages		
	c. Vor Start	d. Während Start	e. Während Reiseflug	f. Während Landung	g. Nach Landung	h. Gesamt Mittell	i. Während Aufsetzen	1. j. Tag N = 5	2. j. Tag N = 4	3. j. Tag N = 3
k. ..gende .. 59)	76,8	78,9	78,1	83,9	78,7	79,3	90,1			
l. ..tflie- ..le .. 59)	78,9	79,5	78,8	80,8	80,0	79,6	84,9			
m. ..mt ..el	77,9	79,2	78,5	82,4	79,4	79,5	87,5	79,4	79,2	79,8
n. ..ste Ein- ..erte	118,0	122,1	118,5	123,4	117,0	115,5	126,0			
k. ..gende	15,6	17,3	15,5	17,4	14,9	16,1	18,9			
l. ..tflie- ..e	15,4	15,9	15,2	15,8	15,0	15,5	17,1	15,5	15,7	16,3
..mt m. ..el	15,5	16,6	15,3	16,6	14,9	15,8	18,0			
n. ..ste Ein- ..erte	22,8	23,5	20,5	24,3	23,3	21,8	27,0			

o. ..lle 3 Puls- und Atemfrequenzen bei Cockpit-Besatzungsmitgliedern auf der europäischen Kurzstrecke.

Umlauf XB

See page 19 for Key.

p. Flugphase	a. Mittel für die angegebenen Flugphasen (Schläge bzw. Atemzüge/min) c. Vor Start	d. Während Start	e. Während Reiseflug	f. Während Landung	g. Nach Landung	h. Gesamt Mittel	i. Während Aufsetzen	b. Mittel für alle Flüg eines Tages j. 1. Tag N = 4	j. 2. Tag N = 4	j. 3. Ta N =
k. Fliegende (N = 65)	86,6	88,3	89,6	97,1	90,5	90,4	105,0			
l. Nichtfliegende (N = 65)	79,6	81,5	84,2	85,9	84,4	83,1	87,9			
m. Gesamt Mittel	83,1	84,9	86,9	91,8	87,5	86,8	96,5	86,3	87,1	87,1
n. Höchste Einzelwerte	109,0	107,4	108,0	126,0	114,5	110,2	133,0			
k. Fliegende	16,9	19,7	18,4	19,9	16,9	18,4	21,9			
l. Nichtfliegende	17,3	18,3	17,7	17,9	16,2	17,5	19,9			
m. Gesamt Mittel	17,1	18,9	18,0	18,9	16,6	17,9	20,9	17,9	18,4	17,5
n. Höchste Einzelwerte	24,1	23,5	24,9	25,9	24,0	22,6	32,0			

o. **Tabelle 4** **Puls- und Atemfrequenzen bei Cockpit-Besatzungsmitgliedern auf der europäischen Kurzstreck**

Umlauf ZD See page 19 for Key.

p. mlauf XB	a. Mittel für die angegebenen Flugphasen (Steigerung in % des Ruhewertes) c Vor Start	d Während Start	e Während Reiseflug	f Während Landung	g Nach Landung	h Gesamt Mittel	i Während Aufsetzen	b. Mittel für alle Flüge eines Tages 1. j Tag	2. j Tag	3. j Tag
k liegende	14,6	17,7	16,5	25,2	17,4	18,3	34,5			
l ichtflie-ende	14,1	15,0	13,9	16,8	15,7	15,1	22,8			
m esamt ittel	14,4	16,3	15,3	21,0	16,6	16,8	28,5	16,9	15,5	17,6
n öchste Ein-elwerte	39,9	44,8	36,1	41,7	38,8	32,7	44,7			
p mlauf ZD										
k liegende	18,8	20,6	22,4	32,7	23,7	23,5	43,5			
l ichtflie-ende	11,9	14,7	18,5	20,8	18,7	16,9	23,7			
m esamt ittel	15,2	17,7	20,5	27,3	21,3	20	33,8	19,9	20,7	20,6
n öchste Ein-elwerte	41,3	38,2	40,1	63,5	47,3	41,8	79,0			

o abelle 5 Pulsfrequenzen bei Cockpit-Besatzungsmitgliedern auf der europäischen Kurzstrecke (Angaben Umlauf XB und ZD

See page 23 for Key.

Key for Table 5, page 22: a. Average for the flight phases indicated (increase in % of value at rest)

b. Average for all flights on one day

c. Before take-off

d. During take-off

e. While travelling

f. During the landing

g. After landing

h. Total average

i. During touch-down

j. day

k. actively flying personnel

l. non-flying personnel

m. total average

n. maximum individual values

o. Table 5: Pulse Rates for Cockpit Crew Members on the Short European Routes (data in %)

Circuits XB and ZD

p. circuit

Key for Table 6, page 24:

a. Data on amount in micrograms/hour

b. Increase in comparison to control group in %

c. day

d. unconjugated

e. conjugated

f. adrenaline

g. noradrenaline

h. average

i. Table 6: The Hormone Secretion during the Flights and the Percentual Increase in Comparison to the Control Group (N = 10).

Circuit XB

Key for Table 7, page 25: Same as Key for Table 6 page 24 (above) with one exception -

i. Table 7: The Hormone Secretion during the Flights and the Percentual Increase in Comparison to the Control Group (N = 12).

Circuit ZD

	a Mengenangaben in µg/Std.			b. Zunahme im Vergleich zur Kontrollgruppe in %		
	1.c Tag 7 - 14 h	2.c Tag 7 - 15 h	3c Tag 7 - 12 h	1.c Tag	2.c Tag	3.c Tag
17-OHCS unkonj. d	16,59	17,18	15,41	58,29	87,37	39,67
17-OHCS konj. e	155,85	166,11	176,01	62,61	98,07	88,36
f Adrenalin unkonj.	10,28	14,42	13,47	114,48	184,39	160,19
f Adre[illegible] konj e	33,13	35,92	33,20	20,72	49,62	29,15
g Noradrenalin unkonj. d	22,15	23,50	28,55	97,68	139,36	143,33
g Noradrenalin konj. e	62,67	75,80	87,85	96,38	171,42	161,77
			h. Mittel:	75,03	121,71	103,75

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i.

Tabelle 6 Die Hormonausscheidung während der Flüge und ihre prozentuale Zunahme im Vergleich zur Kontrollgruppe (N = 10).

See page 23 for Key.

Umlauf XB

	[a]Mengenangaben in µg/Std.			[b]Zunahme im Vergleich zur Kontrollgruppe in %		
	1.[c] Tag	2.[c] Tag	3.[c] Tag			
	13 - 22.30 h	15 - 23 h	15.45 - 23 h	1.[c] Tag	2.[c] Tag	3.[c] Tag
-CHCS conj.[d]	7,81	11,15	9,23	42,97	156,32	112,06
-CHCS ij.[e]	111,99	148,35	125,45	39,08	100,83	69,83
[f]enalin conj.[d]	9,13	9,04	10,69	65,42	99,30	98,37
[f]enalin ij.[e]	24,94	25,41	41,94	9,95	6,48	47,99
[g]adrenalin conj.[d]	13,76	18,29	16,21	49,91	87,28	39,76
[g]adrenalin ij.[e]	46,78	62,79	48,71	40,67	97,97	53,60
			[h]Mittel:	41,34	91,36	70,27

[i]elle 7 Die Hormonausscheidung während der Flüge und ihre prozentuale Zunahme im Vergleich zur Kontrollgruppe (N = 12).

See page 23 for Key.

Umlauf ZD

	a. Mengenangaben in µg/Std.			b. Zunahme im Vergleich zur Kontrollgruppe in %		
	1. cTag 21 - 22 h	2. cTag 22 - 22 h	3. cTag 22 - 12 h	1. cTag	2. cTag	3. cTag
17-OHCS unkonj. d	9,31	11,07	9,69	35,15	60,77	28,82
17-OHCS konj. e	111,85	125,31	101,73	39,06	55,80	41,71
Adrenalin f unkonj. d	0,78	0,97	0,71	86,33	132,53	126,04
Adrenalin f konj. e	2,74	3,10	2,69	8,43	22,72	22,74
Noradrenalin g unkonj. d	1,42	1,70	1,60	40,43	66,27	81,97
Noradrenalin g konj. e	5,22	6,00	5,19	78,85	105,64	100,01
			h Mittel:	48,04	73,96	66,88

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Tabelle 8 [i] Die Hormonausscheidung pro Tag und ihre prozentuale Zunahme im Vergleich zur Kontrollgrupp bei Cockpit-Besatzungsmitgliedern auf der europäischen Kurzstrecke (N = 10).

See page 27 for Key.

Umlauf XB

Key for Table 8, page 26:

a. Data on amount in micrograms/hour

b. Increase in comparison to control group in %

c. day

d. unconjugated

e. conjugated

f. adrenaline

g. noradrenaline

h. average

i. Table 8: Hormone Secretion per Day and the Percentual Increase in Comparison to the Control Group for Cockpit Crew Members on the Short European Routes (N = 10).

Circuit XB

Key for Table 9, page 28: same as for Table 8, page 26 (above) with one exception

i. Table 9: Hormone Secretion per Day and the Percentual Increase in Comparison to the Control Group for Cockpit Crew Members on the Short European Routes (N = 12).

Circuit ZD

Key for Table 10, page 29:

a. Data on amount in micrograms/hour

b. Percentual increase in comparison to sleep periods before the flights

c. Before flying

d. After first flight day

e. After second flight day

f. unconjugated

g. conjugated

h. adrenaline

i. noradrenaline

j. average

k. Table 10: Hormone Secretion during the Periods of Sleep after the first and second flight day and the percentual increase in comparison to periods of sleep before the flights (N = 10).

Circuit XB

	a. Mengenangaben in µg/Std.			b. Zunahme im Vergleich zur Kontrollgruppe in %		
	1. [c] Tag 2 - 2 h	2. [c] Tag 2 - 2 h	3. [c] Tag 2 - 23 h	1. [c] Tag	2. [c] Tag	3. [c] Tag
7-OHCS nkonj. [d]	7,63	9,30	9,05	10,81	34,96	20,28
7-OHCS onj. [e]	90,94	113,08	120,23	13,07	40,59	50,72
[f] irenalin ikonj. [d]	0,60	0,68	0,73	42,42	63,97	70,11
[f] irenalin onj. [e]	2,69	2,64	2,92	6,41	4,51	13,89
[g] oradrenalin ikonj. [d]	1,16	1,50	1,50	13,61	47,18	45,04
[g] radrenalin	3,77	4,78	4,84	29,24	63,98	64,50
			[h] Mittel:	19,26	42,53	45,72

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[i] belle 9 Die Hormonausscheidung pro Tag und ihre prozentuale Zunahme im Vergleich zur Kontrollgruppe bei Cockpit-Besatzungsmitgliedern auf der europäischen Kurzs recke (N = 12).

Umlauf ZD

See page 27 for Key.

	a. Mengenangaben in µg/Std.			b. Prozentuale Zunahme im Verglei Schlafperiode vor den Flüge	
	c. vor den Flügen	d nach 1. Flugtag	e nach 2. Flugtag	d nach 1. Flugtag	e nach 2. Flugtag
17-OHCS unkonj. f	4,12	5,12	5,73	24,08	39,05
17-OHCS konj. g	48,63	62,19	68,03	27,88	39,88
h Adrenalin f unkonj.	0,33	0,42	0,39	26,83	16,70
h Adrenalin g konj.	2,30	2,50	2,64	9,07	14,82
i Noradrenalin f unkonj.	0,71	0,78	0,99	10,08	39,13
i Noradrenalin g konj.	2,28	3,01	3,60	31,27	56,70
			j Mittel:	21,54	34,38

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k
Tabelle 10 Die Hormonausscheidung während der Schlafperioden nach dem 1. und 2. Flugtag und ihre prozentuale Zunahme im Vergleich zur Schlafperiode vor den Flügen (N = 10).

Umlauf XB

See page 27 for Key.

	a Mengenangaben in µg/Std.			b Prozentuale Zunahme im Vergleich zur Schlafperiode vor den Flügen	
c	vor den Flügen	d nach 1. Flugtag	e nach 2. Flugtag	d nach 1. Flugtag	e nach 2. Flugtag
17-OHCS unkonj. f	7,46	10,38	9,87	39,13	32,29
17-OHCS konj. g	68,21	83,86	82,44	22,94	20,85
Adrenalin unkonj.	0,31	0,35	0,32	13,37	4,44
Adrenalin konj.	2,08	2,01	2,16	5,87	3,71
Noradrenalin unkonj.	0,71	0,83	0,84	16,74	18,52
Noradrenalin konj.	2,59	3,62	3,30	39,41	27,20
				j Mittel: 22,91	17,83

k Tabelle 11 Die Hormonausscheidung während der Schlafperioden nach dem 1. und 2. Flugtag und ihre prozentuale Zunahme im Vergleich zur Schlafperiode vor den Flügen (N = 12).

Umlauf ZD

See page 31 for Key.

Key for Table 11, page 30:

a. Data on amount in micrograms/hour

b. Percentual increase in comparison to sleep periods before the flights

c. Before flying

d. After first flight day

e. After second flight day

f. unconjugated

g. conjugated

h. adrenaline

i. noradrenaline

j. average

k. Table 11: Hormone Secretion during the Periods of Sleep after the first and second flight day and the percentual increase in comparison to the periods before the flights (N = 12).

<u>Circuit ZD</u>

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2 Tätigkeit	1 Pulsfrequenzen/min 3 Gruppenmittel absolut	in %	4 Extreme Einzelwerte absolut	in %	5 Autoren
6 Fliegen / Piloten					
7 1. DLH-737					8 Eigene, 1973
9 vormittags (XB):					
10 Gesamtflug	79	18	115	33	
11 Landeanflug	84	25	123	42	
12 Min. d. Aufsetzens	90	34	126	45	
13 nachmittags (ZD):					
10 Gesamtflug	90	24	110	42	
11 Landeanflug	97	33	126	64	
12 Min. d. Aufsetzens	105	44	133	79	
2. BOAC-707					Nicholson et al.,
11 Landeanflug:					
Delhi	90	15 Einzelwerte			
Frankfurt	105				
14 Unmittelb. b. Aufsetzen:					
Delhi	130				
Frankfurt	140				
16 3. Militär-Jet					Hoffmann et al., 1
17 Ausbildungsflüge:					
18 Gesamt-Start		60			
19 Gesamt-Landung		60			
Traffic-Pattern		36			
Gunnery	123	76	164	140	
20 4. Militär-Jet					Lewis et al., 1967
21 Bombenflüge:					
22 Beim Bombenwerfen	113		170		
10 Gesamtflug	95				
5. Do 27					Hoffmann, 1967
23 Start oder Landung		20-30			
24 6. Hubschrauber:					Raabe, 1969
25 Rollstart		30			
26 Rollandung		40			
27 Senkrechtstart		40			
28 Senkrechtlandung		50			
29 Autorotation 360°					
30 mit power recovery		67			
31 ohne power recovery		138	150-200		
24 7. Hubschrauber					Shane, 1967
32 (Fluglehrer):					
10 Gesamtflug	92		125		

33 and 34

32 Prozentzahlen als Steigerung ...

See following page for Key.

Key for Table 12a, page 32:

1. Pulse rate/min
2. activity
3. group average - absolute value in %
4. extreme individual value - absolute value in %
5. authors
6. flying/pilots
7. German Lufthansa B 737
8. our own report
9. in the morning
10. total flight
11. approach
12. minute of touch-down
13. in the afternoon
14. immediately after landing
15. individual values
16. military jet
17. training flights
18. total - take-off
19. total - landing
20. military jet
21. bombing missions
22. when releasing the bombs
23. take-off or landing
24. helicopter
25. rolling start
26. rolling landing
27. vertical take-off
28. vertical landing
29. autorotation 30. with power recovery 31. without
32. flight instructor
33. percentages as increase in relation to the value at rest
34. Table 12a: Pulse Rate in various Aircraft

[1] Pulsfrequenz/min

[2] Tätigkeit	[3] Gruppenmittel absolut	in %	[4] Extreme Einzelwerte absolut	in %	[5] Autoren
[6] Flugsimulator					
[7] 8. F 104-Instrumentenflug					[8] Eigene, 1968 (Kroll, 1972; Ste hoff, 1972)
[9] vormittags:					
[10] Gesamtflug	83	19	102		
[11] nachmittags:					
[10] Gesamtflug	89	24	116		
[12] 9. Simulator					Hasbrook, et al., 1
[13] Einmotorig -Instrumentenflug					
[14] Anflug, Middle Marker	93				
[15] Fallschirmspringen					
[16] 10. Springer m. großer Erfahrung:					Shane, 1968
[17] Freier Fall	166				
[18] Öffnen	179				
[19] Landen	163				
[20] 11. Springer ohne Erfahrung:					Reid et al., 1970
[18] Öffnen			220		
[21] Kraftfahren					
[22] 12. PKW-Langstrecke		10-20	110		Meyer, 1969
[23] 13. Berufsrennfahren:					Taggart; zit. n. P aureum, Boehringer
[24] Letzte Min. v. Start	180				
[25] Während Rennen			200		
[26] Andere					
[27] 14. Gleiche Personen wie bei 7:					
[28] Verwaltungsarbeit	87		108		Shane, 1967
[29] Kraftfahren	86		110		
[30] Essen	90		115		

[31] Prozentzahlen als Steigerung gegenüber dem Ruhewert.

See following page for Key.

[34] [32] Tabelle 12b Pulsfrequenzen bei verschiedenen Tätigkeiten.

Key for Table 12b, page 34:

1. Pulse rate/min
2. Activity
3. Group average - absolute value in %
4. Extreme individual value - absolute value in %
5. authors
6. flight simulator
7. F 104 instrument flight
8. our own report
9. in the morning
10. total flight
11. in the afternoon
12. simulator
13. single-engine aircraft instrument flight
14. approach
15. parachuting
16. parachutist with much experience
17. free fall
18. opening the parachute
19. landing
20. parachutist without experience
21. car drivers
22. long-distance trip in a passenger car
23. professional racing drivers
24. last minute before the start
25. during the race
26. others
27. Same persons as under 7
28. administration work
29. driving a car
30. eating
31. percentages as the increase in relation to the value at rest
32. Table 12b: Pulse rates during various activities.